



# ***Identification of Potential Air Traffic Complexity Factors Through Field Observations at Boston ATC Facilities***

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# Introduction

- **Project Goal**
  - ❑ Develop models / metrics of air traffic complexity.
- **Motivation for Visits**
  - ❑ Identify potential complexity factors through direct observation.
- **Visit Details:**
  - ❑ 3 trips to Boston TRACON.
  - ❑ 1 trip to Boston ARTCC (ZBW).
- **Activities**
  - ❑ Interviews with training department.
  - ❑ Discussions with traffic management unit personnel.
  - ❑ “Plugged in” next to working controllers:
    - ◆ Observing traffic patterns,
    - ◆ Gathering explanations of control actions
    - ◆ Probing perceptions of sector characteristics



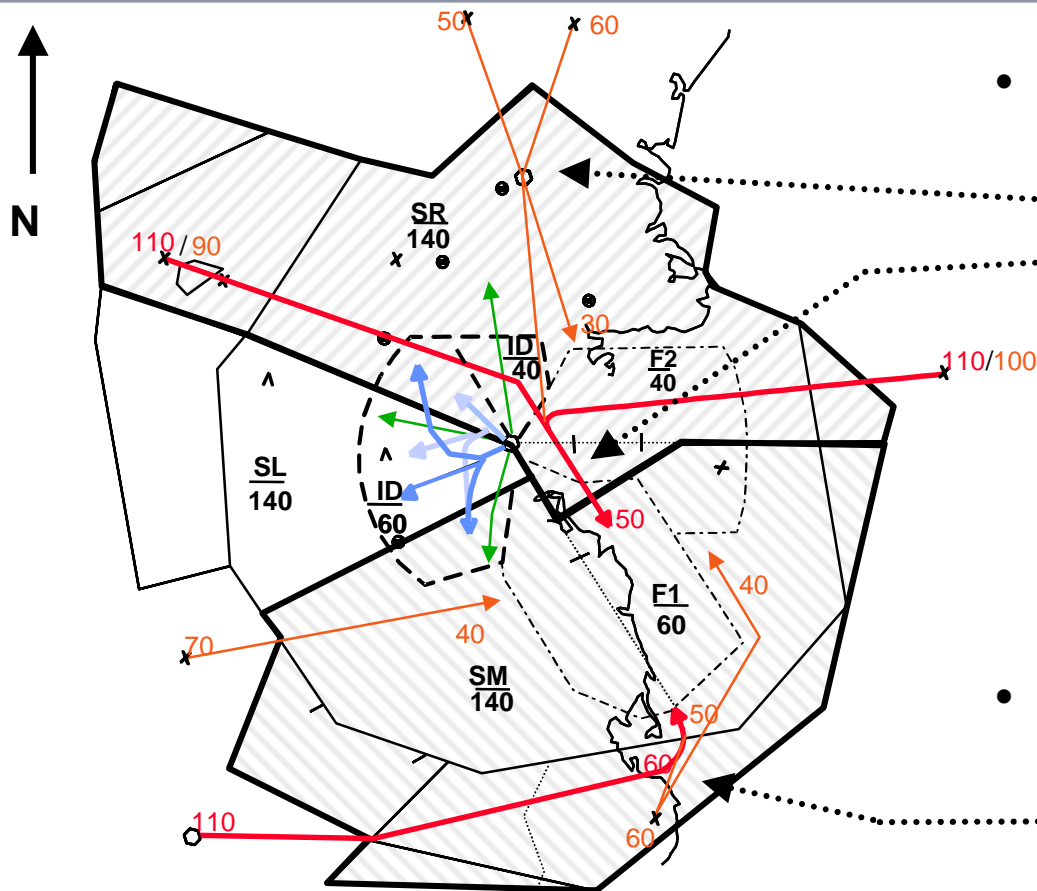
# The “Hardest” Position

- **Asked controllers to identify the “hardest” position in the Boston TRACON**
  - ☐ Spent time with 8 different controllers.
  - ☐ General consensus: **Rockport.**
- **Reasons identified by controllers:**
  - ☐ Presence of both arrivals & departures:
    - ◆ Most aircraft under control are in transition.
  - ☐ Multiple sources of aircraft:
    - ◆ 4 arrival fixes.
  - ☐ Sometimes merging up to six flows into one.
  - ☐ Typical aircraft paths can sometimes require substantial coordination activities.

# Comparing Positions:

## Rockport and Plymouth

(Configuration: Landing 33 L/R, Departing 27 / 33 L/R)



### • Rockport Position



#### □ Merging Activities:

- ◆ Combining 2 Prop flows.
- ◆ All other flows combined into single downwind feed to the Final Controller (F1)

#### □ Coordination Activities

- ◆ Departures held below arrival flow can interact with operations at satellite airport (Bedford)

### • Plymouth Position



#### □ Merging Activities

- ◆ Only one merging operation  
⇒ Prop flow into jet flow

### Departure Flows:

#### Jets

27 (dark blue)  
33L (light blue)

#### Props

All (Green)

### Arrival Flows:

#### Jets

33L (Red)

#### Props

33 L/R (Orange)



# Potential Complexity Factors

- **Structural Factors**

*Factors that reflect the underlying structural properties of the airspace.*

- ☐ Airspace Properties
- ☐ Standard Flow Structures

- **Aircraft Distribution Factors**

*Factors that are dependent on the dynamic positions and velocities of aircraft in the airspace.*

- ☐ Density Factors
- ☐ Encounter Factors
- ☐ Characteristics of the Aircraft in the Airspace.

- **Operations Factors**

*Factors affecting the operating procedures in the airspace.*

- ☐ Operational Constraints
- ☐ Co-ordination / Communication Issues

- **Other**

*Factors not captured by any of the previous categories.*

- ☐ Human Factors
- ☐ Miscellaneous



# Structural Factors

*Factors that reflect the underlying structural properties of the region of airspace.*

- **Airspace Properties**

*Factors related to the static geometric properties of the region of airspace.*

- ☐ Sector size.  
*The total airspace nominally available for use by the controller.*
- ☐ Sector shape and the presence of shelves.  
*The sector shape is defined by the 3D-boundary of the physical airspace. Shelves are small blocks of airspace on the boundary, of a limited altitude range, added to the sector.*
- ☐ Altitude levels available.  
*The number of discrete altitude levels that a controller, using solely vertical separation criteria, could assign to aircraft within the airspace.*
- ☐ Spatial distribution of airways / jet-routes.  
*How the airways are laid out within the airspace? How densely packed are the airways? How many intersections between airways?*

- **Standard Flow Structures**

*Factors describing the standard flight paths, e.g. “flows,” of aircraft within the airspace.*

- ☐ Number and strength of flows.  
*How many flows in the sector? How many aircraft are typically in each flow?*
- ☐ Directional distribution of flows.  
*How many directions do the flows represent? How are the flows aligned in the airspace?*
- ☐ Intra-flow properties:  
*How complicated is the trajectory of the flow? Are there multiple turns, altitude changes?*
- ☐ Inter-flow relationships:  
*If there exist multiple flows in the airspace, how do they interact with each other? Are there lateral crossings? Intersection points? “Merge points” where two flows join together?*



# Aircraft Distribution Factors

*Factors that are dependent on the dynamic positions and velocities of aircraft in the airspace.*

- **Density Factors**

*Factors related to the density of aircraft in the airspace.*

- ☐ Number of aircraft.
- ☐ Local traffic density.

*Factor to capture any localized concentrations of aircraft. Specifically, to capture situations such as “piggy-backs” where two aircraft enter a sector with only altitude separation. Comments from controllers indicated this can make a sector more complex.*

- **Encounter Factors**

*Factors related to inter-aircraft relationships, e.g. encounters or potential conflicts.*

- ☐ Spatial geometry of encounters.  
*The relative angles, speeds, distance of closest approach, of any two or more aircraft within the airspace. Also included is consideration of the difficulty in solving any encounter (e.g. two aircraft being within 10 miles of each other may simply be following each other in trail as opposed to the greater complexity represented by two aircraft being on converging courses).*
- ☐ Location of an encounter.  
*How close is an encounter to the boundary of the airspace? Are there other constraints on how the controller could react to the encounter?*
- ☐ Time duration of an encounter.  
*How long does the encounter last?*



# Aircraft Distribution Factors

*Factors that are dependent on the dynamic positions and velocities of aircraft in the airspace.*

- **Characteristics of Aircraft in the Airspace**

*Factors related to the properties of aircraft within the airspace.*

- ☐ **Aircraft performance.**

*Differences in aircraft type (heavy jets vs. Cessnas) and pilot proficiency (ATP vs. student pilot) will produce a range in the performance characteristics of aircraft within the airspace (i.e. climb rates, turn rates etc...). Both the range of characteristics and the capability of individual aircraft are important.*

- ☐ **Aircraft speeds.**

*The range of aircraft speeds within the airspace. Observations indicate that the importance of this factor scales with sector transit time: in a small sector, speed differentials are not as difficult to handle as in a larger sector.*

- ☐ **Altitude levels occupied.**

*The range of altitude levels occupied by aircraft within the airspace. This factor is a measure of how much of the controller's altitude "resources" are available.*

- ☐ **Number of aircraft in transition.**

*The number of aircraft changing their trajectory through turns, altitude changes, or speed adjustments.*

- ☐ **Sector transit time.**

*The time an individual aircraft spends within the sector boundaries.*





# Operations Factors

*Factors capturing the effects of the operating procedures used in the airspace.*

- **Operational Constraints**

*Factors that impact the operational flexibility available to the controller.*

- ☐ Available airspace:

*The airspace that a controller has available can be restricted by operational constraints such as: weather, especially the presence of thunder-storms, the availability of special-use or restricted airspace, and the availability and current use of airspace designated for holding activities.*

- ☐ Procedural restrictions:

*The flexibility of the controller can also be restricted by the presence of procedural restrictions such as noise abatement procedures, and the requirement to meet traffic management restrictions such as miles-in-trail spacing.*

- **Co-ordination / Communication Issues**

*Factors capturing how coordination and communication operational procedures can impact the complexity of the airspace.*

- ☐ Point-outs

*Point-outs occur when a controller co-ordinates with adjacent controllers to 'borrow' some airspace for a temporary period of time. Complexity factors include how often point-outs occur, and how many controllers coordination is required with.*

- ☐ Handoffs.

*Transferring control of an aircraft to or from adjacent controllers.*

- ☐ Frequency congestion:

*The complexity of a piece of airspace will be influenced by the number of instructions a controller is trying to give, particularly when this number exceeds the capacity of the radio communications system.*

# Other

*Any factors not captured by any of the previous categories.*

- **Human Factors**

***Factors dealing with influences on how a controller interacts with the airspace.***

- ☐ Interactions with fellow controllers.

*The “team” nature of the facility was continuously stressed, especially in the TRACON environment. The actions of, and interactions with, controllers of adjacent airspace will be factors determining the complexity of the airspace.*

- ☐ Impact of support tools.

*Tools used to provide support to controllers, e.g. URET, can change the degree of, and type of knowledge about the interactions between aircraft in the airspace.*

- **Miscellaneous**

***Factors that do not fit into any particular category.***

- ☐ Monitoring requirements.

*Factor to capture the complexity associated with the monitoring of the traffic situation.*

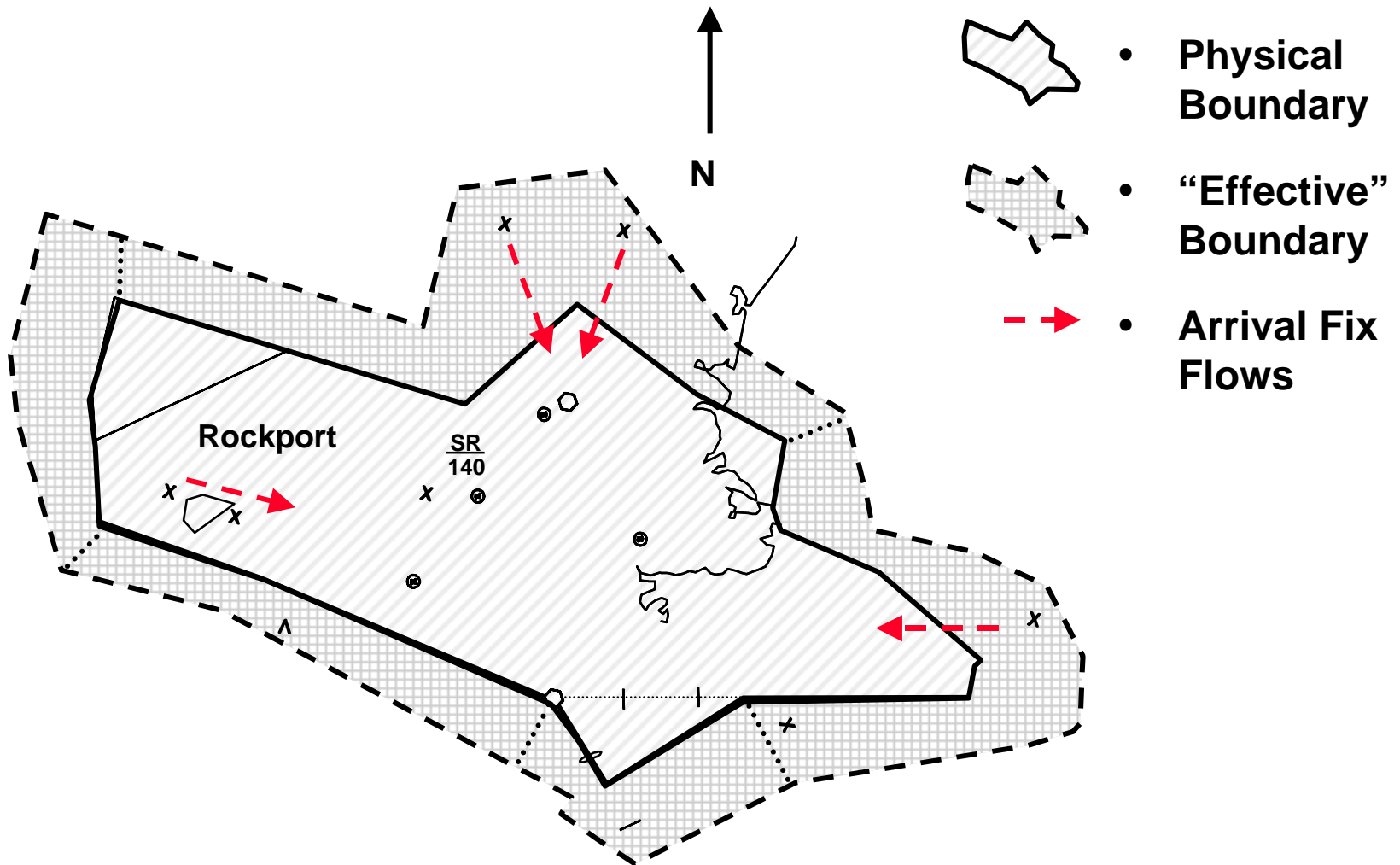
- ☐ Availability of “intent” information.

*The knowledge of future aircraft trajectories was cited as an important input into the making of control decisions.*

- ☐ “Physical” Boundary and “Effective” Boundary

*Field observations indicate that a controller is actively aware of a far broader region of airspace than the physically defined region that he or she is personally responsible for. Thus, in considering factors related to airspace properties, the physical definition of the sector should not be considered as defining the region over which these factors should be evaluated.*

# “Effective” Boundary of Rockport Position





# References

- **“Dynamic Density: An Air Traffic Management Metric”, I.V. Laudeman, S.G. Shelden, R. Branstrom, C.L. Brasil.**
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- **“An Evaluation of Air Traffic Control Complexity, Final Report” Wyndemere Corporation, Boulder, Colorado, 1996.**